



**Competency 1.4 Radiation protection personnel shall demonstrate a working level knowledge of the engineered radiological controls and design criteria.**

### **1. Supporting Knowledge and/or Skills**

- a. Discuss radiological protection considerations in layout design for nuclear facilities.
- b. Discuss the radiological protection considerations in the design and selection of components for nuclear facilities.
- c. Discuss the concerns associated with the selection of materials and the associated finishes for components used in radiological control areas.
- d. Discuss the differences and associated applications between permanent and temporary engineered radiological controls.

### **2. Summary**

Nuclear facilities must be designed to facilitate operation, maintenance, inspections, radiation, and radiological control. The public, workers, and the environment are protected by designing facilities to:

- isolate radioactive from non-radioactive areas
- provide shielding to protect workers from direct radiation
- control and minimize radioactive effluents to the environment
- limit access to hazardous areas
- control and minimize the release of radioactivity from systems designed to contain radioactive materials
- facilitate area and component decontamination.



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When designing and selecting components for a nuclear facility, care must be taken in the following areas:

- Include an evaluation of radiological conditions to which the components may be subjected or under which the components will operate. For example, electronic components for use near a reactor must be capable of operating properly in high gamma fields or in high neutron fluence rates. Not only must equipment be designed to withstand external radiological conditions, components must be capable of containing the radioactive material they are designed to process or transport. If high dose rates from penetrating radiation are expected, components must be adequately shielded. Shielding must provide adequate attenuation and minimize radiation streaming and hot spots associated with joints and corners in shielding material.
- Pipes and ducts should not have stagnation areas where deposition of radioactive material may occur. The use of any component or system that has corners, crevices, etc., where deposition could occur, should be avoided when possible.
- For ease of decontamination:
  - equipment should be readily accessible and easy to disassemble (as necessary for maintenance). During the design or selection process, contact or remote maintenance must be considered. Contact maintenance is less expensive, but may result in higher personnel exposures. Remote maintenance is expensive and typically must be included in initial facility design.
  - materials and material finishes must be relatively smooth and non-porous. Wood and other porous construction materials should be avoided for areas likely to become contaminated. Concrete is highly porous and very difficult to decontaminate unless a non-porous finish is applied. The use of strippable paint is recommended for areas and components requiring frequent decontamination.
- For components used in the handling or storage of fissile materials, component geometry and the use of neutron absorbers should be considered for criticality prevention.
- Piping, valves, pumps, and other components in nuclear facility systems should contribute as little as possible to radioactive source terms. Consideration must be given to the corrosiveness of materials that may contact component surfaces and the radiological effect of corrosion layer buildup and transport throughout facility systems. For example, the use of stellite valve seats in reactor systems has been largely discontinued due to the high concentration of cobalt in stellite. Valve seat wear and corrosion results in the transport of higher than normal levels of cobalt to the reactor, where the cobalt may be activated and transported throughout the reactor coolant system. Materials for use near operating reactors must also be selected to minimize activation as a result of neutron exposure.



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- Temporary controls, such as temporary shielding or portable ventilation devices, are typically a response to unanticipated problems. Permanent controls, such as shield walls and permanent ventilation systems, are established with facility design and startup to ensure that worker safety and regulatory compliance is part of the radiological design basis of the facility. Temporary controls may be removed when the problem is corrected. Permanent controls typically cannot be changed unless the regulatory requirements that initially made them necessary are changed.

DOE Order 6430.1A provides general design criteria for use in the planning, designing, or acquiring of a facility for DOE. When considering the radiological concerns associated with the design, construction, and operation of containment and confinement systems, the Order (p. 13-9) states, "special facilities shall be designed to minimize personnel exposures to external and internal radiological hazards, provide adequate radiation monitoring and alarm systems, and provide adequate space for health physics activities. Primary radiation protection shall be provided by the use of engineered controls (e.g., confinement, ventilation, remote handling, equipment layout, and shielding); secondary radiation protection shall be provided by administrative control. As Low As Reasonably Achievable (ALARA) concepts shall be applied to minimize exposures where cost-effective."

### **3. Self-Study Scenarios/Activities and Solutions**

#### ***Activity 1***

##### **Review**

- DOE Order 6430.1A, *General Design Requirements*

A health physics graduate student has been given an assignment of designing a nuclear facility. What radiological considerations must the student take into account completing this assignment?



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***Your Solution :***

[illegible]



### **Activity 1, Solution**

(Any reasonable paraphrase of the following is acceptable.)

The basic ALARA philosophy can be described as limiting personnel and environmental radiation exposures to the lowest levels commensurate with sound economic and social considerations. However, the ALARA philosophy assumes that no radiation exposure should occur without a positive benefit, considering technological, economic, and societal factors. This statement implies that there is some risk, however small, with any exposure to radiation. One should always look for ways to reduce radiation exposure, as long as the cost of the consideration does not exceed the possible cost of the potential dose savings.

**One of the best ways to achieve ALARA is by designing it into a facility from the very beginning.** This ALARA engineering (or radiological engineering) ensures that radiation exposures are minimized when the facility goes into operation and that maintenance, repair, or modifications in the facility can be done safely and without significant contamination or radiation hazards.

Each facility will have its own unique set of concerns, so no list can be inclusive, but here is a list of are a few considerations for various aspects of building design that can serve as a starting point for an ALARA review.

- Reduce crud deposition
- Reduce airborne sources and gaseous leakage
- Use proper air flow
- Provide for proper contamination control measures
- Facilitate decontamination of:
  - Equipment decontamination
  - Personnel decontamination
- Radwaste
  - Equipment
  - Plugging
- Sampling
- Monitoring
- Instrumentation
- Access Control
  - Traffic
  - Radiological Areas
- Shielding
- Penetrations



- Routing of Ducts, Pipes, and Cables or Conduit (DPCs)
- Proper Separation
- Proper Segregation
- Proper Placement of Equipment
- Redundancy
- Accessibility
- Laydown and storage
- Equipment
  - Reliability
  - Qualification
- Human Factors
  - Visual aids
  - Auditory factors
  - Human physical characteristics
  - Prevention of human error

#### **4. Suggested Additional Readings and/or Courses**

##### Readings

- Argonne National Laboratory. (1988). *Department of Energy Operational Health Physics Training* (ANL-88-26). Argonne, IL: Author.
- Cember, Herman (1996). *Introduction to Health Physics* (3rd ed.). McGraw-Hill: New York.
- DOE Order 6430.1A, Referenced Documents Index, p. 17-35.
- Gollnick, D. A. (1988). *Basic Radiation Protection Technology* (2nd ed.), Pacific Radiation Corporation: Altadena, CA.

##### Courses

**NOTE:** See Appendix B for additional course information

- DOE/EH-0450 (Revision 0), *Radiological Assessors Training (for Auditors and Inspectors) - Fundamental Radiological Control*, sponsored by the Office of Defense Programs, DOE
- DOE/EH-0450 (Revision 0), *Radiological Assessors Training (for Auditors and Inspectors) - Applied Radiological Control*, sponsored by the Office of Defense Programs, DOE
- *Applied Health Physics* -- Oak Ridge Institute for Science and Education
- *Radiation Protection Functional Area Qualification Standard Training* -- GTS Duratek



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